ORDOVICIAN STROMATOPOROIDS FROM NEW SOUTH WALES

by B. D. WEBBY

ABSTRACT. The stromatoporoid faunas from the Ordovician limestones in the central-west part of New South Wales are described, and a local biostratigraphical scheme using stromatoporoids and corals for correlation of the limestones is outlined.

The lower member of the Cliefden Caves Limestone and equivalent horizons has yielded only labechiids. The six species include representatives of *Pseudostylodictyon*, *Rosenella*, *Labechia*, *Cystistroma*, and *Stratodictyon* gen. nov. (comprising *S. ozakii* sp. nov. and *S. columnare* sp. nov.). The upper part of the middle member and the upper member of the Cliefden Caves Limestone, and its correlatives, have produced a fauna comprising four labechiid species (including *Pseudostylodictyon inequale* sp. nov. and *Cystostroma cliefdenense* sp. nov.) and four clathrodictyid species (including *Ecclimadictyon nestori* sp. nov.). In addition, the upper member contains a distinctive new form, *Cliefdenella etheridgei* gen. et sp. nov., the sole representative of the new Family Cliefdenellidae.

Approximately half the described species, including both labechiids and clathrodictyids, exhibit Asian and east European affinities; the others appear to be endemic. None of the species is closely related to North American forms. At generic level, *Cystistroma*, *Stratodictyon*, and *Cliefdenella* can only be doubtfully regarded as endemic to Australia. Excluding the supposed Cambrian stromatoporoids, the occurrences of *Clathrodictyon* and *Ecclimadictyon* are the earliest known, of possible Lower Eastonian (= middle Caradoc or 'Trentonian') age.

APART from the account of *Cystistroma donnellii* by Etheridge (1895), no Ordovician stromatoporoids have been described previously from Australia. The type specimens of *C. donnellii* were probably collected originally from an horizon at Fossil Hill, in the lower member of the Cliefden Caves Limestone (Stevens 1952). The stromatoporoids described are mainly from the Cliefden Caves Limestone, though they are supplemented by material from other Ordovician limestones in central-western New South Wales (text-fig. 1), particularly from the Regan's Creek Limestone, the Reedy Creek Limestone, the Bowan Park Limestone, the Cargo Creek Limestone, the Canomodine Limestone, and an unnamed limestone near Gunningbland, 16 miles west of Parkes.

STROMATOPOROID DISTRIBUTION

Three stratigraphically distinct units in the lower member of the Cliefden Caves Limestone contain labechiid stromatoporoids (text-fig. 2). The 'lower coral' unit has produced *Stratodictyon ozakii* gen. et sp. nov., *Labechia regularis* Yabe and Sugiyama, and *Cystistroma donnellii*; the 'mixed fauna' unit contains *Pseudostylodictyon* aff. *poshanense* Ozaki, *S. columnare* sp. nov., *Rosenella woyuensis* Ozaki, *L. regularis*, and *C. donnellii*; and the 'upper big shell' unit contains *R. woyuensis*. *Cystostroma cliefdenense* sp. nov. is the next species to appear, towards the middle of the middle member. It occurs with *P. inequale* sp. nov., *L. variabilis* Yabe and Sugiyama, and the first clathrodictyids, *Clathrodictyon* aff. *mammillatum* (Schmidt), *C.* cf. *microundulatum* Nestor, and *Ecclimadictyon nestori* sp. nov. in the upper part of the middle member. In the 'Island' unit of the upper member, the clathrodictyids, *C.* cf. *microundulatum*, *E. nestori*, and *E. anzassensis* (Khalfina) occur with *Cliefdenella etheridgei* gen. et sp. nov.

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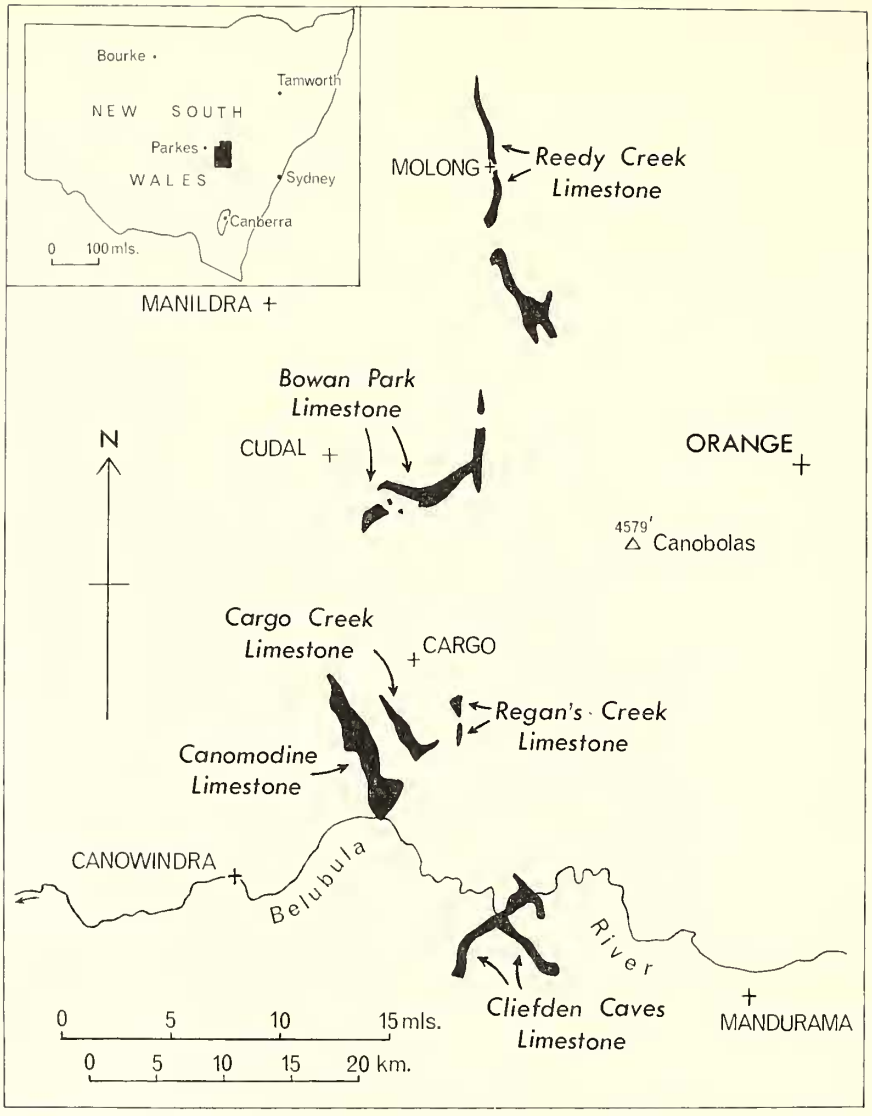


TEXT-FIG. 1. Map showing location of main stromatoporoid-bearing Ordovician limestones in New South Wales.

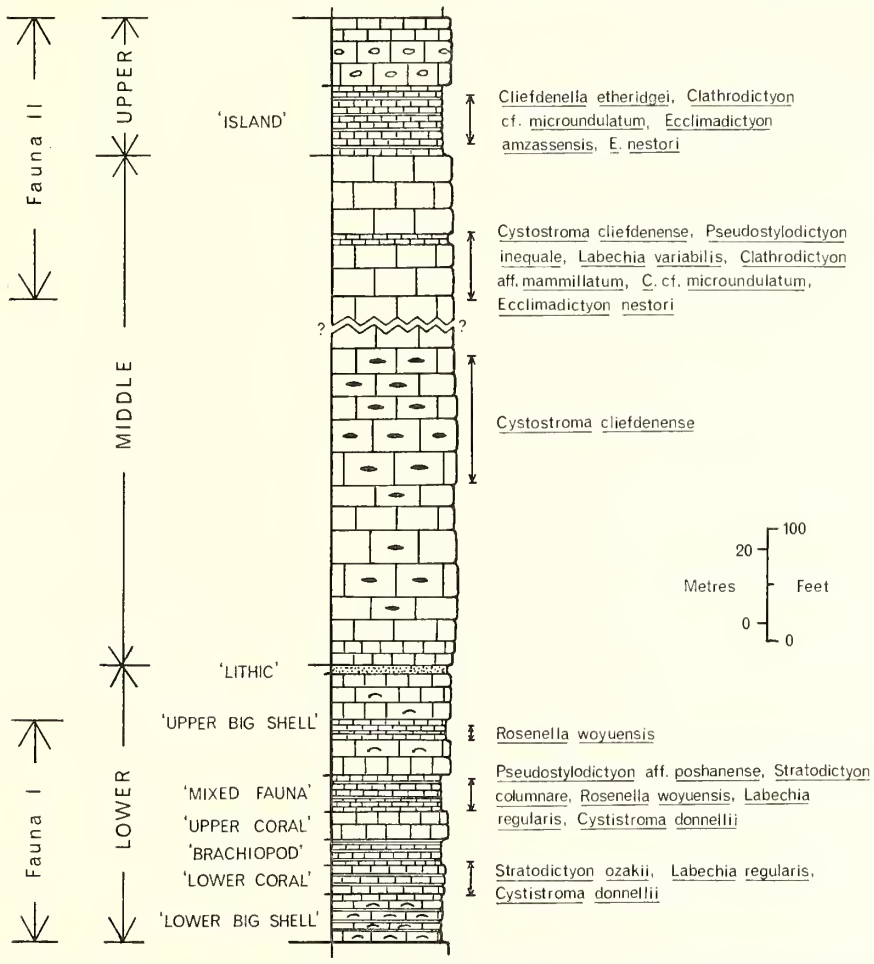
A similar distribution occurs in the Regan's Creek Limestone (Stevens 1956) with the labechiids, *L. regularis* and *C. donnellii* at the base, *C. cliefdenense* and *Cryptophragmus*? sp. through the middle, *L. variabilis* at the top of the middle, and the clathrodictyid *E. amzassensis* in the upper part of the limestone.

L. regularis and *C. donnellii* have been collected from the lower part of the Reedy Creek Limestone (Adrian 1956; Phillips Ross 1961) near Molong. Further north, near Eurimbula, *E. amzassensis* and *E. nestori* occur in isolated limestone lenses.

E. amzassensis also comes from a thinly bedded unit in the lower part of the Cargo

Creek Limestone (Stevens 1950), and from a similar horizon in the Canomodine Limestone (Stevens 1950).

In the Bowan Park Limestone (Stevens 1956), *S. columnare* and *Cryptophragmus*? sp. come from near the base of the formation, and *Clathrodictyon* aff. *mammillatum* and *E.*



TEXT-FIG. 2. Stratigraphical column showing subdivisions, stromatoporoid occurrences, and distribution of 'faunas' in the Cliefden Caves Limestone. A fault in the main section east of the Large Flat is depicted by the break in the column. It seems to have little significance, at most involving the loss of only a few feet of beds.

amzassensis occur sporadically through it from just below the prominent thinly bedded unit near the stratigraphical middle, to the top of the succession. In addition, *E. nestori* comes from just above and below the thinly bedded unit, *L. variabilis* from just below it, and *P. inequale* from immediately above it. *C.* cf. *microundulatum* and *P. inequale* have also been collected from the upper part of the formation.

Further west a belt of Ordovician limestone extends from Billabong (= Goobang) Creek (Packham 1967) to Gunningbland, and thence seems to swing eastwards towards

Parkes. *Cliefdenella etheridgei* has been collected from a locality 1 mile north of Gunningbland.

STROMATOPOROID AND CORAL BIOSTRATIGRAPHY

In her study of the Ordovician tabulate corals of New South Wales, Hill (1957) observed certain differences in the faunal content of the respective limestones. The differences between the faunas of the Cliefden Caves Limestone and the Bowan Park and Regan's Creek Limestones may be attributed to random sampling of different parts of the respective successions, and have no biostratigraphical significance. However, the fauna containing *Plasmoporella inflata* Hill and *Plasmopora cargoensis* Hill, from the Cargo Creek and Canomodine Limestones, is stratigraphically distinct from the faunas described by her from the Cliefden Caves, Bowan Park, and Regan's Creek Limestones.

It is now possible to recognize three biostratigraphically distinct stromatoporoid and coral faunas, here referred to as Faunas I, II, and III. These have proved to be useful for the correlation of the limestones in the region west of Orange (text-fig. 1). Detailed work has shown the strikingly similar sequence of faunas through each local succession. Hill's fauna with *Plasmoporella inflata* and *Plasmopora cargoensis* belongs to the youngest, Fauna III.

There are, however, some anomalies in using the faunas to correlate the limestones near Gunningbland, some 55 miles to the west, and near Tamworth, in northern New South Wales, and this emphasizes the essentially local nature of the biostratigraphical scheme.

In terms of Packham's (1960; 1967) palaeogeographical reconstructions, the limestones west of Orange were formed on the Molong Geanticline. To the east lay the Hill End Trough and to the west the Cowra Trough. Further west, the limestones at Gunningbland accumulated on the Parkes Platform. The faunal scheme is entirely workable in the region of the Molong Geanticline, but beyond is less certain.

The stromatoporoid and coral faunas are as follows (text-fig. 3):

Fauna I

Diagnosis. Characterized by abundant labechiids, like *L. regularis* and *C. donnellii*, a varied tabulate element including several species of *Tetradium*, and one rugose coral (a large species of *Tryplasma*).

Distribution. Typically developed in lower member of Cliefden Caves Limestone; also occurs in lower part of Regan's Creek and Reedy Creek Limestones. Slightly modified fauna is represented in lower part of Bowan Park Limestone, consisting of several species of *Tetradium* but lacking labechiids.

Fauna II

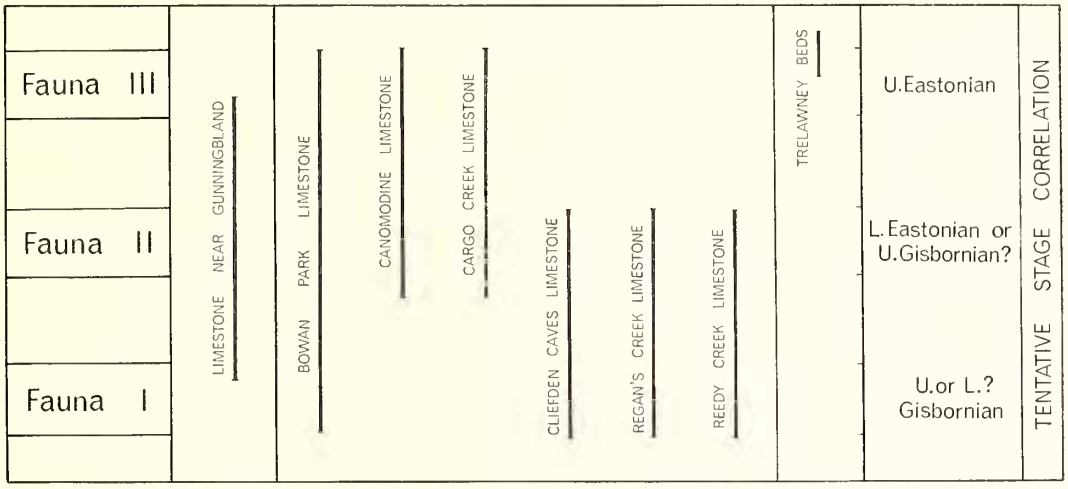
Diagnosis. Distinguished by first appearance of clathrodictyids, particularly *E. anzassensis* and *E. nestori*, by occurrence of *C. etheridgei*, by abundant heliolitids, and by first appearance of *Palaeophyllum*. Lichenariids and tetradiids are less common, and apparently make their last appearance in this fauna.

Distribution. Characteristic of upper part of middle member and upper member of Cliefden Caves Limestone, and upper part of Regan's Creek Limestone. Also occurs through middle units of Bowan Park Limestone, in limestone lenses correlated with Reedy Creek Limestone near Eurimbula, and in lower part of Cargo Creek and Canomodine Limestones.

Fauna III

Diagnosis. Characterized by first appearance of halysitids, favositids, solitary streptelasmatids, and favistellids, particularly *Favistina*. *Plasmoporella inflata* is also diagnostic.

Distribution. Middle and upper parts of Cargo Creek and Canomodine Limestones. Similar fauna, though lacking *Favistina*, found in upper part of Bowan Park Limestone. *Favistina* collected from limestone breccias of Malongulli Formation overlying Cliefden Caves Limestone.



TEXT-FIG. 3. Chart showing occurrence of Faunas I–III in the Ordovician limestones of New South Wales, and their tentative correlation with the Victorian graptolite stages.

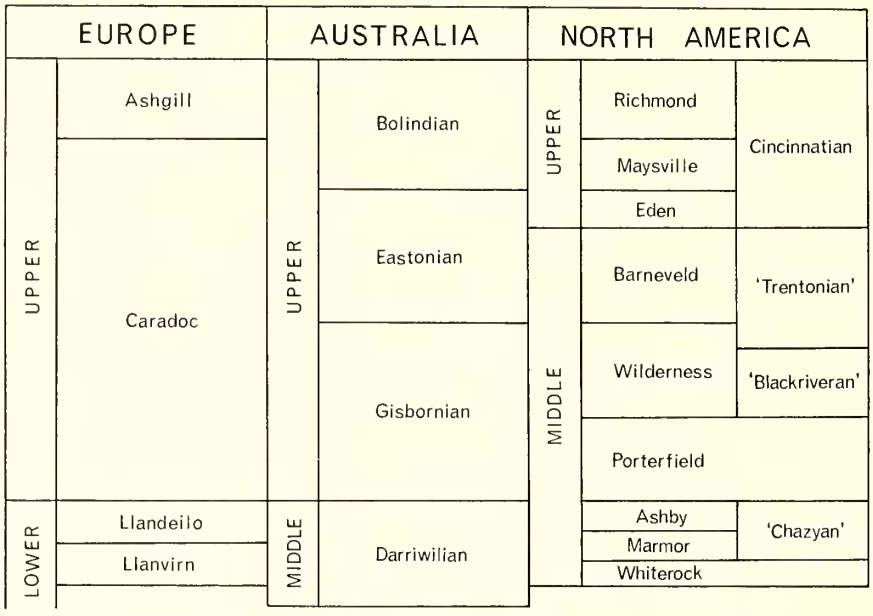
The Bowan Park Limestone has representatives of all the faunas in superposition. Though it lacks the variety of fauna and lithology in the lower part, there can be little doubt that it is at least in part equivalent to the lower member of the Cliefden Caves Limestone. Fauna II is well represented in the middle thinly bedded unit and through the more massive beds just above and below this unit. Fauna III occurs in the upper part of the limestone, though *Favistina* is lacking. Its absence may be due to local environmental differences rather than implying that the uppermost beds are not developed, for the same species of *Halysites* occurs in the uppermost beds of both the Canomodine and Bowan Park Limestones.

Fauna I is well represented in the lower member, and Fauna II in the upper part of the middle member and upper member of the Cliefden Caves Limestone (text-fig. 2). Conodonts studied by Dr. G. H. Packham (pers. comm.) from the lower member suggest an upper Porterfield? or lower Wilderness age (text-fig. 4).

The overlying Malongulli Formation is interpreted as a deeper-water graptolitic shale succession with lenses of limestone breccia containing *Favistina*, possibly derived by slumping from neighbouring shallow-water carbonate banks. The species of *Favistina* seems to be conspecific with the form found in the upper part of the Cargo Creek and Canomodine Limestones. Apparently the slumps from fringing carbonate banks took place during or immediately after the accumulation of Fauna III. The present distance between the Cliefden Caves Limestone and the Cargo Creek and Canomodine Limestones is less than 8 miles, but at least one great north–south trending thrust fault, the

Columbine Mountain fault (Stevens 1950) separates the two areas, and they may have been much further apart prior to folding and thrusting.

Graptolites from the Malongulli Formation have been determined by Sherrard (1954) as belonging to the *Nemagraptus gracilis* Zone. Moors (1966) restudied this fauna and concluded that it exhibited an Eastonian aspect, possibly of the *Dicranograptus hians* Zone. The underlying Cliefden Caves Limestone may therefore range from the Gisbornian to the Eastonian.



TEXT-FIG. 4. Tentative correlation table for the middle and upper parts of the Ordovician of Europe, Australia, and North America. Based on Cooper (1956), Thomas (1960), Whittington and Williams (1964), and Whittington (1966). The old subdivisions in the North American succession are shown in quotation marks.

Packham (1967) recorded a varied fauna, including *Tetradium* and heliolitids, from Billabong Creek. He tentatively correlated it with the upper part of the Wilderness (= Upper Gisbornian, in terms of the Victorian graptolite succession). Near Gunningbland, *Cliefdenella etheridgei*, *Streptelasma* sp., *Palaeophyllum* sp., and *Plasmoporella inflata* have been collected together. The species of *Palaeophyllum* appears to be conspecific with the form occurring in the upper member of the Cliefden Caves Limestone. The fauna thus includes diagnostic elements of both Faunas II and III. Possibly *Streptelasma* and *P. inflata* appear earlier in the limestones of the Parkes Platform than the limestones to the east, on the Molong Geanticline. The intervening Cowra Trough, or some marked differences in the environments of the Parkes Platform and Molong Geanticline, may have affected the faunal distribution.

Philip (1966) described an isolated occurrence of Ordovician limestone south-east of Tamworth, northern New South Wales. Named the Trelawney Beds, they have produced an abundant fauna, including *Favistina*, *Palaeophyllum*, *Streptelasma*, and helio-

litids. The coral fauna, though apparently lacking halysitids and favositids, resembles that found in the upper part of the Cargo Creek and Canomodine Limestones, and seems to belong to Fauna III. Philip observed that the conodonts included forms previously described from strata of Barneveld to Maysville age in North America. He suggested correlation of the Trelawney Beds with the upper Caradoc, or with the Eastonian of the Victorian type succession (text-fig. 4).

Thus, Faunas I and II are tentatively regarded as Lower? or Upper Gisbornian and Upper Gisbornian? or Lower Eastonian, respectively, and Fauna III is Upper Eastonian (text-fig. 3). There is no evidence at present to suggest that Fauna III extends into the Bolindian, though the possibility cannot be entirely ruled out.

ZOOGEOGRAPHICAL RELATIONSHIPS

Little is known about the stromatoporoids from the Gordon Limestone of Tasmania, and no systematic work has been published on the fauna. Banks (1962, pp. 164, 173–4) reported *Cryptophragmus* and 'aulacerid hydrozoans' from the Chudleigh–Mole Creek area, and the Queenstown area. The 'aulacerids' near Chudleigh occur with *Catenipora*, *Tryplasma*, and other fossils in the upper beds of the limestone. Several other localities are mentioned by Banks (1957, p. 50) as having stromatoporoids.

In New South Wales, the stromatoporoids are dominantly encrusting laminar and hemispherical forms. The only records of a cylindrical form are *Cryptophragmus*? sp., from the middle part of the Regan's Creek Limestone and from the lower part of the Bowan Park Limestone. The significance of the specific references to Tasmanian forms with cylindrical coenostea remains in doubt. In the departmental collection at Sydney there are laminar-hemispherical specimens of *Rosenella* and *Labechia* from the Gordon Limestone. The virtual lack of post-Eastonian limestones in New South Wales may explain the absence of *Aulacera*. In North America species of *Aulacera* are limited to the Richmond (Galloway and St. Jean 1961, p. 25), which would correlate with Upper Bolindian in the Victorian sequence (text-fig. 4).

The stromatoporoid faunas of New South Wales exhibit the closest relationships to Asian and east European faunas described by Yabe and Sugiyama (1930), Ozaki (1938), Yavorsky (1955), Khalfina (1960), and Nestor (1964). Six of the fifteen described species bear resemblances to Asian, and two to east European forms. Four of these, *Rosenella woyuensis*, *Labechia regularis*, *L. variabilis*, and *Ecclimadictyon amzassensis* are synonymous with Asian species, two others exhibit affinities to *Pseudostylodictyon poshanense* (Asian) and *Clathrodictyon mammillatum* (east European) respectively, and one is comparable to *C. microundulatum* (east European). One further species, *P. inequale*, is closely related to a Chinese species described by Ozaki (1938, p. 216) as *Rosenella*? sp. nov. Only the genera *Stratodictyon* and *Cliefdenella* appear to be endemic to Australia.

Cystistroma donnellii shows some similarities to *Stromatocerium canadense* Nicholson and Murie from North America (Galloway and St. Jean 1961, p. 62), but none of the other New South Wales forms is closely related to a North American species. The only positively assigned genera common to the Ordovician of North America (Galloway and St. Jean 1961) and New South Wales are *Cystostroma*, *Rosenella*, and *Labechia*.

The clathrodictyid genus *Ecclimadictyon*, which makes its appearance in Fauna II (Lower Eastonian = middle Caradoc), first occurs in south-west Siberia in horizons

correlated with the upper Caradoc, and in Estonia in the Porkuni stage (upper Ashgill). *Clathrodictyon*, also found in Fauna II, first appears in Estonia in the Vormsi stage (lower–middle Ashgill). Ordovician clathrodictyids have not been reported outside the Australian–Siberian–Estonian region. Vlasov (1961) described a species of *Clathrodictyon*, *C. formozavae*, from the Cambrian of West Sayan, south-west Siberia; Nestor (1966) thought it resembled the internal structure of *Ecclimadictyon*, but it remains too incompletely known for its precise affinities to be settled. Other Cambrian species formerly regarded as clathrodictyids are now assigned to the family Korovinellidae Khalfina 1960.

The trilobites also exhibit strong Asian affinities in the Upper Ordovician (Caradoc). Whittington's (1966) '*Encrinurella*' fauna is considered to be restricted mainly to Australia and south-east Asia (particularly Burma, South China, and Korea), though Dean (1967, p. 33) noted that it may reach into eastern Turkey in the late Caradoc and overlap with a fauna of the 'trinucleid–homalonotid' group, having a Bohemian aspect. The '*Encrinurella*' fauna is reported as occurring in the lower member of the Cliefden Caves Limestone and in theMalongulli Formation of New South Wales (Stevens 1952), and in the Gordon Limestone of Tasmania (Banks 1962).

Packham (1967) observed that most of the macrofossil genera in the Ordovician fauna at Billabong Creek are found in the Ordovician of North America, but *Pliomerina* is a notable exception, occurring in south-east and central Asia.

Relatively strong faunal linkages between New South Wales and North America are suggested by some other Ordovician groups, notably polyzoans (Phillips Ross 1961), conodonts (Philip 1966; Packham 1967), and edrioblastoids (Webby 1968).

SYSTEMATIC PALAEONTOLOGY

The registration numbers of specimens in the University of Sydney palaeontological collections have the prefix SUP.

Order STROMATOPOROIDEA
Family LABECHIIDAE Nicholson 1885
Genus CYSTOSTROMA Galloway and St. Jean 1957

Type species. C. vermontense Galloway and St. Jean 1957.

Cystostroma cliefdenense sp. nov.

Plate 117, figs. 1–5

Material. 8 specimens from upper part of middle member of Cliefden Caves Limestone, Licking Hole Creek (SUP 28258–60), from eastern side of Large Flat (SUP 28261–4), and from middle part of Regan's Creek Limestone (SUP 28162).

Holotype. SUP 28258; other specimens designated paratypes.

Description. Coenosteum mainly laminar, but sometimes laminar-hemispherical in form; up to 140 × 60 mm. diameter, 50 mm. high. Broad, updomed mamelons may occur, about 15–20 mm. in diameter. Latilaminae developed in some specimens, from 1·5 to 5·5 mm. high.

Vertical section shows small cysts of variable size, chiefly with length slightly more than twice height; cysts usually 0·25–1·0 mm. long, 0·12–0·20 mm. high though

exceptionally in mamelons, may be 2 mm. long and 1 mm. high. Between 12 and 22 cysts occur in 2 mm. vertically. Cyst wall mainly 15–20 μ thick. Latilaminae separated by mud and calcite infilling. No astrorhizae or villi visible. In tangential section, cysts exhibit round to polygonal outline and variable size.

Remarks. C. cliefdenense, although not particularly well preserved, is clearly distinguishable from other known species of *Cystostroma*. It resembles both *C. minimum* (Parks 1910) from the 'Trentonian' of Kentucky, and *C. fritzae* Galloway and St. Jean 1961 from the Richmond of Ontario, but differs in exhibiting, on average, smaller cysts. *C. minimum* has astrorhizae and *C. fritzae* smaller mamelons.

Genus PSEUDOSTYLODICTYON Ozaki 1938

Type species. P. poshanense Ozaki 1938.

Discussion. Galloway (1957, p. 424) interpreted the structures on the cysts of *Pseudostylodictyon* as crenulations rather than denticles. This may be true of some species, but in the original description of the type species, Ozaki (1938, p. 209) referred to short pillar-like structures, often thicker than cysts, and not extending beyond one interlaminar space, or more frequently 'mere projections' from the underlying cysts, suggesting denticles.

Pseudostylodictyon is similar to *Rosenella* but differs in exhibiting more gently arched to flat or sagging, low, elongate cysts, which sometimes approximate to laminae. It may be distinguished from *Cystostroma* by having less arcuate cysts and denticles. *Aulacera* Plummer 1843 has a cylindrical coenosteum with large axial cysts, smaller arcuate cysts in medial and outer zones, and sporadically developed pillars in the outer zone (Galloway and St. Jean 1961, p. 21).

Pseudostylodictyon aff. *poshanense* Ozaki 1938

Plate 117, fig. 6; Plate 118, figs. 1–3

Material. 5 specimens (SUP 26226; 26232–5) from 'mixed fauna' unit of lower member of Cliefden Caves Limestone, west of shearing shed, Boonderoo.

Description. Coenosteum hemispherical to encrusting, up to 170 mm. diameter, 160 mm. high. Latilaminae exhibited at irregular intervals through coenosteum. No astrorhizae.

Vertical section shows prominent mamelons with arching of latilaminae across them. Preservation of finer elements in coenosteum is not complete, especially within mamelons. Cysts of variable size, updomed at mamelons and broadly sagging between; cysts long, low, and gently convex away from mamelons. Denticles occur on upper surfaces of cysts and rarely on outer surfaces of mamelons. Mamelons usually 1–2 mm. wide, spaced 3–8 mm. apart. Number of cysts varies from 4 to 14 in 2 mm. vertically; occasional large cysts 1·8–8 mm. long, 0·5–2 mm. high. Thickness of cyst wall varies from 10 to 40 μ; mainly about 20 μ. In tangential section, mamelons are round; denticles show as fine specks.

Remarks. P. aff. *poshanense* ranges from a finer variety (Pl. 118, figs. 1, 2) to coarser varieties (Pl. 117, fig. 6; Pl. 118, fig. 3). It has affinities with *P. poshanense* from the Ordovician of Shantung (Ozaki 1938, p. 208), but is distinguished by narrower and more

erect mamelons. *P.* aff. *poshanense* is not closely comparable with any of the North American species of *Pseudostylodictyon*? described by Galloway and St. Jean (1961).

Pseudostylodictyon inequale sp. nov.

Plate 119, figs. 1–3

Material. 3 specimens (SUP 28252–4) from upper part of middle member of Cliefden Caves Limestone, Licking Hole Creek; 1 specimen (SUP 29141) from just above middle thinly bedded unit of Bowan Park Limestone, Quondong; 1 specimen (SUP 29134) from upper part of limestone at Malachi's Hill.

Holotype. SUP 28252; other specimens designated paratypes.

Description. Coenosteum hemispherical to laminar, up to 90 mm. diameter, 85 mm. high. In vertical section, cysts very variable in size, from large gently convex plates up to 20 mm. long and 4 mm. high, to long, low cysts resembling laminae, spaced about 12–16 in 2 mm. vertically. Long, low cysts occur in groups arranged parallel to one another, lying between scattered larger cysts. Cyst wall usually about 20–25 μ thick, but exceptionally 120 μ. Denticles prominent on upper surface of cysts in some areas; especially conspicuous where they project into sediment infilling of a large overlying cyst; seen to extend 0·2 mm. above upper surface of cyst. Mamelons not clearly differentiated. In tangential section denticles appear as dots spaced about 0·1 mm. apart; diameter 20–60 μ.

Remarks. P. inequale bears close similarities to a stromatoporoid from the Middle? Ordovician of Shantung described by Ozaki (1938, p. 216) as *Rosenella*? sp. nov. Galloway (1957, p. 424) assigned Ozaki's species to *Pseudostylodictyon*, evidently because it exhibited the frequent grouping of parallel rows of long, low cysts simulating laminae. The Shantung species is closely related to *P. inequale* but differs in having mamelons.

EXPLANATION OF PLATE 117

Figs. 1–4. *Cystostroma cliefdenense* sp. nov., ×10, middle member, Cliefden Caves Limestone, Licking Hole Creek. 1, SUP 28259, paratype, vertical section showing rhythmic alternation of latilaminae and calcite with sediment-filled zones. 2–4, SUP 28258, holotype; 2, vertical section exhibiting typical arrangement of cysts in coenosteum; 3, vertical section showing mamelon with large associated cysts; 4, tangential section.

Fig. 5. *Cystostroma cliefdenense* sp. nov., SUP 28162, paratype, ×10, vertical section; middle part of Regan's Creek Limestone.

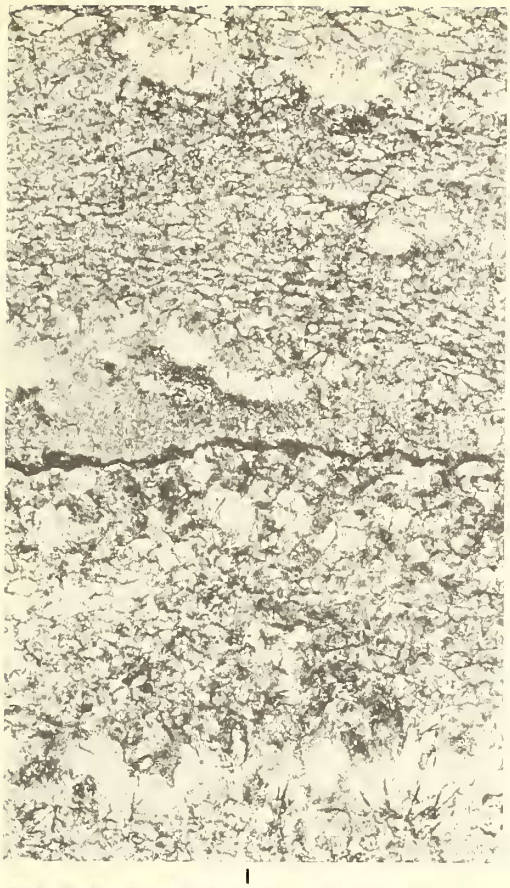
Fig. 6. *Pseudostylodictyon* aff. *poshanense* Ozaki, SUP 26235, ×5, vertical section exhibiting conical-shaped mamelons and denticles on upper surface of the large cysts. From 'mixed fauna' unit, lower member, Cliefden Caves Limestone, west of shearing shed, Boonderoo.

EXPLANATION OF PLATE 118

All figures from 'mixed fauna' unit, lower member, Cliefden Caves Limestone, west of shearing shed, Boonderoo.

Figs. 1–3. *Pseudostylodictyon* aff. *poshanense* Ozaki. 1, 2, SUP 26226, ×5; 1, vertical section showing small and large cysts; 2, tangential section. 3, SUP 26234, ×5, vertical section.

Figs. 4–6. *Stratodictyon columnare* sp. nov., SUP 26229, holotype. 4, vertical section showing latilaminae and mamelons, ×5. 5, vertical section showing rows of fine, long, low cysts and poorly developed short, denticle-like pillars, ×10. 6, tangential section exhibiting arched rows of cysts around mamelons and dark specks which represent small pillars, ×10.



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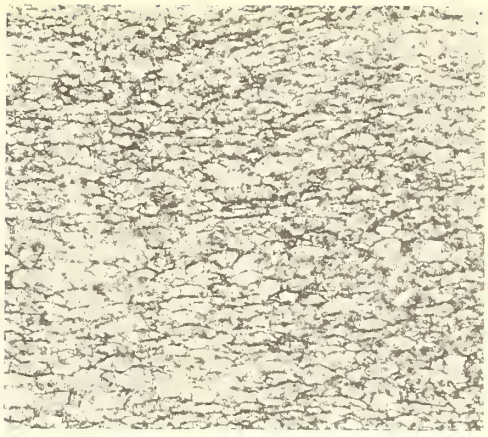

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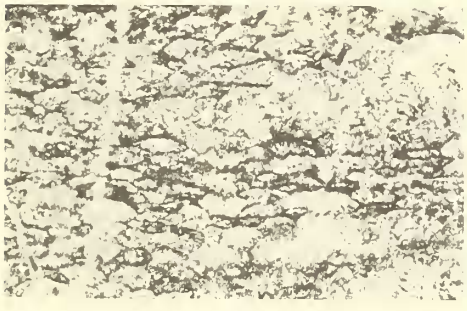

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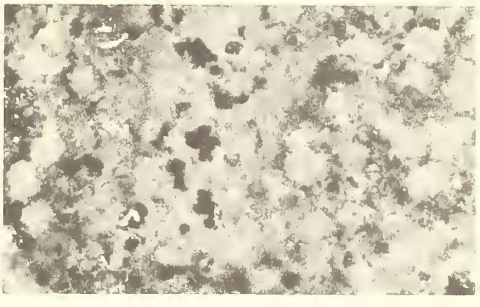

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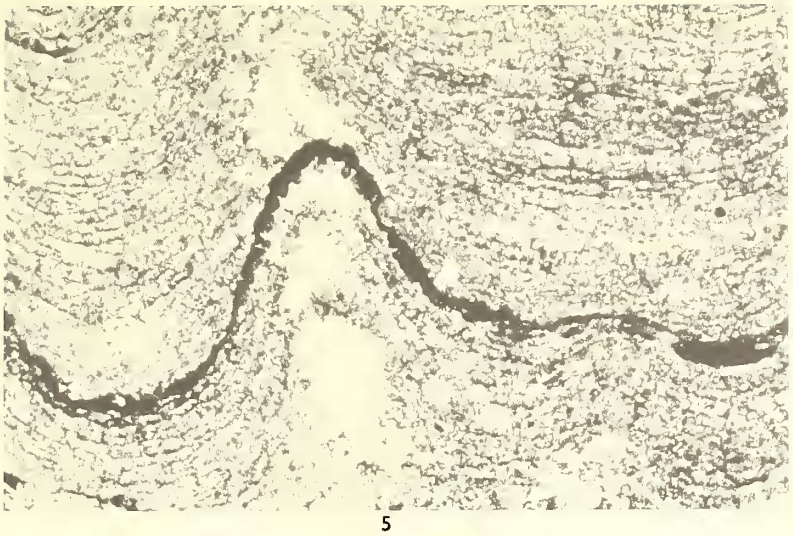
WEBBY, Ordovician stromatoporoids from New South Wales



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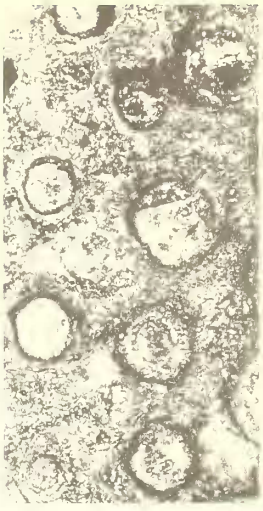

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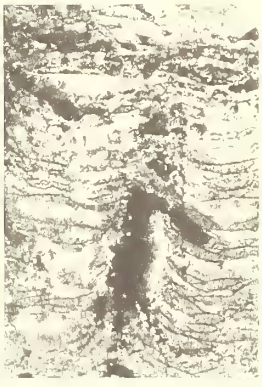

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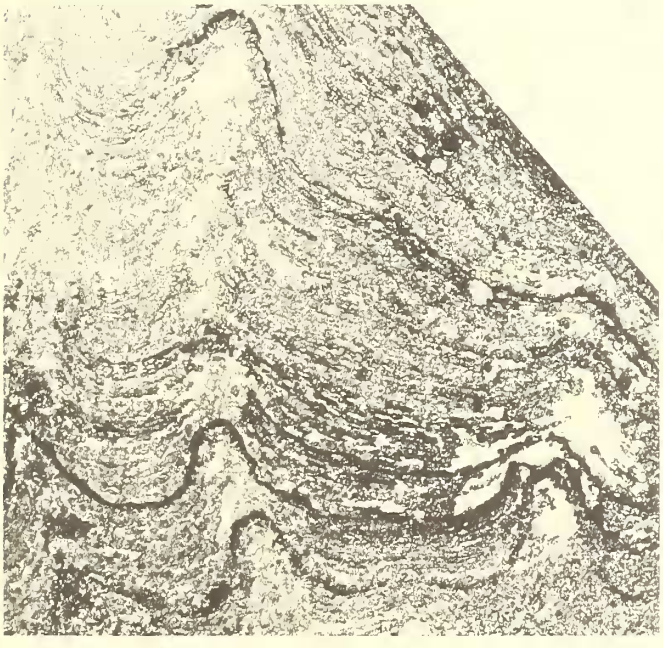

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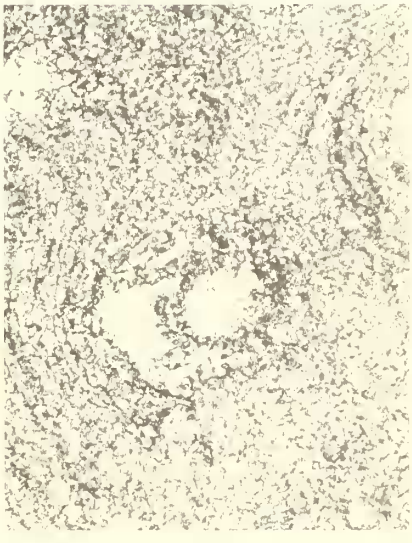

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WEBBY, Ordovician stromatoporoids from New South Wales

Genus STRATODICTYON gen. nov.

Type species. S. ozakii sp. nov.

Diagnosis. Encrusting, laminar to hemispherical coenosteum, with latilaminae, relatively long, low cysts in regular rows resembling laminae, and small, discontinuous pillars. Mamelons may be present or absent. Scattered astrorhizae also occur.

Discussion. The short pillars extending vertically across up to 10 cysts and the presence of scattered astrorhizal canals distinguish *Stratodictyon* from *Pseudostylodictyon*. *Aulacera* has small pillars in the outer zone of its cylindrical coenosteum, but the columnar form is taken by Galloway (1957, p. 423) to be one of the fundamentally diagnostic features of the genus. It is uncertain whether *Aulacera* exhibited astrorhizae or not. Galloway (1957, p. 422) reported them to be rare or absent, but Galloway and St. Jean (1961, p. 21) stated 'astrorhizae absent'.

Plumatalinia Nestor 1960 also seems to be a related genus, but the columns are formed of fine subreticulate tissue, and astrorhizae are absent (Nestor 1964). In the mamelon columns of *Stratodictyon columnare* sp. nov., the rows of cysts are updomed and the pillars diverge outwards.

Stratodictyon ozakii sp. nov.

Plate 119, figs. 4–5; Plate 120, figs. 1, 2; Plate 124, fig. 1

Material. Based on 4 specimens (SUP 26247–8, 26252–3) from 'lower coral' unit of lower member of Cliefden Caves Limestone, Licking Hole Creek.

Holotype. SUP 26252; other specimens designated paratypes.

Description. Encrusting to laminar-hemispherical coenosteum, 130 × 100 mm. across, 65 mm. high. Latilaminae prominent, even to gently undulating, usually 1–10 mm. high. Encrusts *Nyctopora*, *Labechia*, *Cystistroma*, and a polyzoan resembling *Prasopora*.

In vertical section rows of long, low cysts approximating to laminae, averaging 16–19 per 2 mm., are visible. Alternating zones of well preserved cysts and poorly calcified elements or calcite through coenosteum. In one specimen (SUP 26248, Pl. 120, fig. 1) numerous closely spaced latilaminae occur, each successively thinning out towards crest of an encrusted *Labechia*, and finally completely mantling it; alga present between two of the latilaminae. Walls of cysts mainly *c.* 20 μ thick. Pillars thicker than cyst walls, flocculent in appearance, 40–50 μ in diameter; seen to extend continuously across up to 7 cysts. In tangential section pillars appear as fine circular specks, mainly spaced 50–150 μ apart. Vague scattered astrorhizal canals observed, mainly *c.* 0·2 mm. wide.

Remarks. S. ozakii is closely allied to *S. columnare*, only differing in lacking mamelons. *Aulacera peichuangensis* Ozaki (1938, p. 217) from the Ordovician of Shantung is remarkably similar in the character of the latilaminae, the long, low cysts, and the moderately persistent pillars of the outer zone, but not in the differentiated axial and outer zones of the cylindrical or dendroid coenosteum.

Stratodictyon columnare sp. nov.

Plate 118, figs. 4–6; Plate 119, fig. 6; Plate 124, fig. 3

Material. 5 specimens (SUP 26227–31) from 'mixed fauna' unit of lower member of Cliefden Caves Limestone, and 1 specimen (SUP 29142) from lower part of Bowan Park Limestone, east of Quondong.

Holotype. SUP 26229; other specimens designated paratypes.

Description. Encrusting to hemispherical coenosteum, up to 140×100 mm. across, 90 mm. high. Mamelons prominent. Latilaminae folded across mamelons, from 1 to 15 mm. high. Encrusts *Coccoseris* and *Labechia*. Algae encrust it, and occur between latilaminae.

Vertical section exhibits rows of long, low cysts resembling laminae, averaging 15–18 per 2 mm. Walls of cysts mainly 15–20 μ thick. Pillars thicker than cyst walls, *c.* 50 μ in diameter; usually only height of interlaminar space, but some more continuous, extending across up to 10 cysts. Structures not well preserved in mamelons, but in one part of holotype (see text-fig. 5) rows of cysts updome and pillars diverge outwards. Mamelons *c.* 1–2 mm. in diameter, spaced *c.* 3–5 mm. apart. Astrorhizal canals scattered in coenosteum. In tangential section, cysts seem to be arranged concentrically around mamelons. Pillars show as fine specks.

Remarks. The close relationships between *S. columnare* and *S. ozakii* are emphasized by one specimen (Pl. 124, fig. 3) which is assigned to *S. columnare*. Its coenosteum lacks mamelons near the encrusted *Coccoseris* but has them away from it.

EXPLANATION OF PLATE 119

Figs. 1–3. *Pseudostylodictyon inequale* sp. nov. 1, 2, SUP 28252, ×10, holotype, upper part of middle member, Cliefden Caves Limestone, Licking Hole Creek. 1, vertical section showing alternations of rows of long, low cysts simulating laminae and large cysts, and prominent denticles. 2, tangential section shows denticles as dark dots. 3, SUP 29134, ×5, paratype, vertical section, upper part of Bowan Park Limestone, Malachi's Hill.

Figs. 4, 5. *Stratodictyon ozakii* gen. et sp. nov., SUP 26252, ×10, holotype, 'lower coral' unit, lower member, Cliefden Caves Limestone, Licking Hole Creek (see also Pl. 124, fig. 1). 4, vertical section showing rows of long, low cysts with scattered short pillars. 5, tangential section exhibiting specks which seem to represent pillars.

Fig. 6. *Stratodictyon columnare* sp. nov., SUP 26227, ×10, paratype, vertical section showing small pillars crossing several rows of cysts. 'Mixed fauna' unit, lower member, Cliefden Caves Limestone, west of shearing shed, Boonderoo.

EXPLANATION OF PLATE 120

Figs. 1, 2. *Stratodictyon ozakii* gen. et sp. nov., SUP 26248, paratype, 'lower coral' unit, lower member, Cliefden Caves Limestone, Licking Hole Creek. 1, vertical section, ×5, showing latilaminae successively thinning towards crest of encrusted specimen of *Labechia regularis*. Darker patch between latilaminae represents a small algal growth. Rows of long, low cysts and small pillars well exhibited in upper parts of coenosteum. 2, tangential section, ×10, exhibiting vague astrorhizal canals in addition to pillars.

Figs. 3–6. *Rosenella woyuensis* Ozaki, 'mixed fauna' unit, lower member, Cliefden Caves Limestone, east of Large Flat. 3, SUP 26216, ×5, vertical section showing rows of large cysts alternating with sediment-filled spaces. 4, SUP 26217, ×5, tangential section showing large mamelon surrounded by cysts. 5, SUP 26216, ×10, vertical section showing denticles on upper surfaces of cysts. 6, SUP 26216, ×5, vertical section showing large cysts, including some infilled with sediment and algal? structures.

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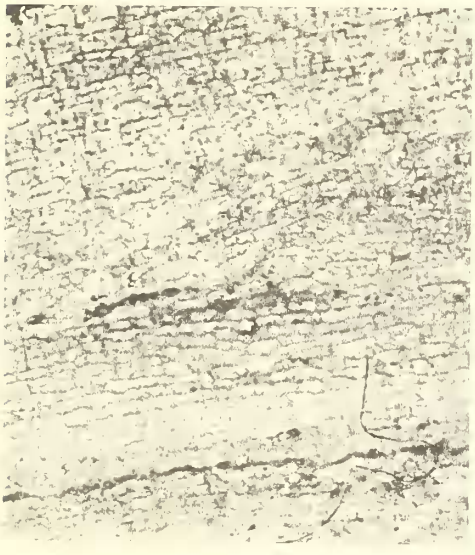

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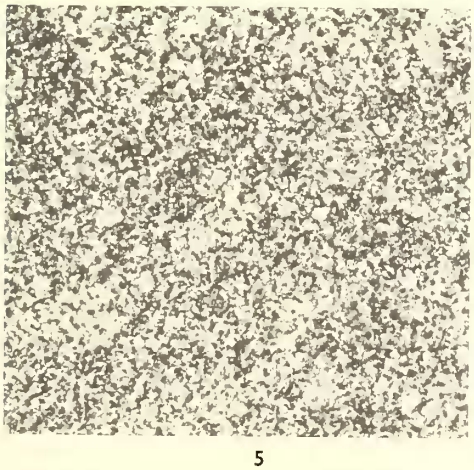

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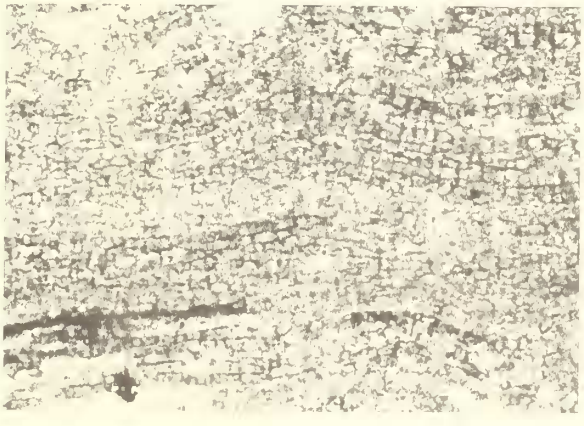

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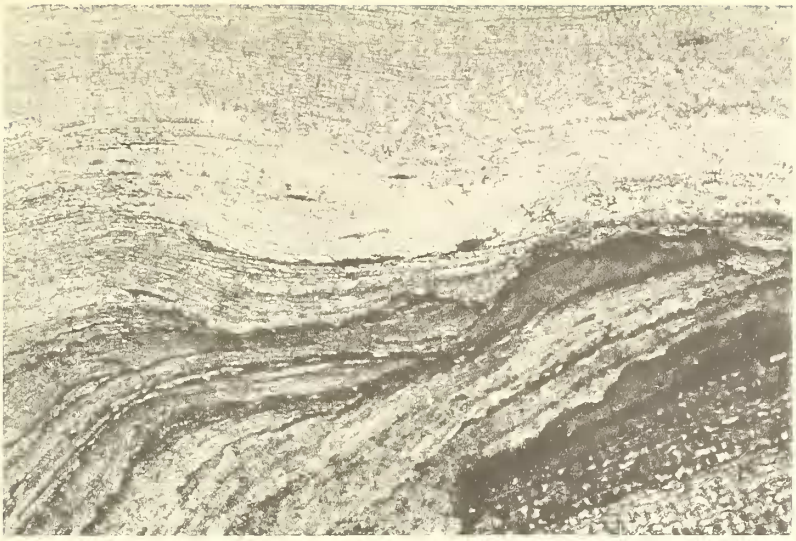
WEBBY, Ordovician stromatoporoids from New South Wales



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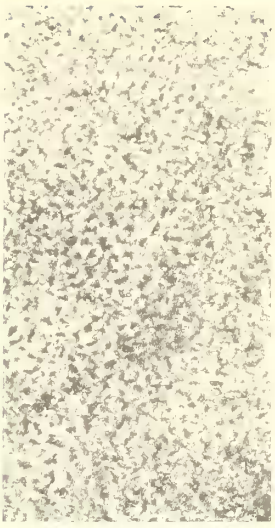

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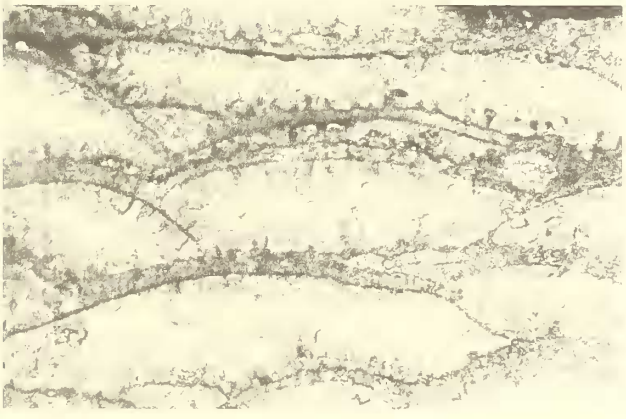

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WEBBY, Ordovician stromatoporoids from New South Wales

Genus ROSENELLA Nicholson 1886

Type species. R. macrocystis Nicholson 1886.

Rosenella woyuensis Ozaki 1938

Plate 120, figs. 3–6

1938 *Rosenella woyuensis* Ozaki, p. 215, pl. 30, fig. 2; pl. 31, fig. 1*a–d*.

Material. 4 specimens (SUP 26214–17) from 'mixed fauna' unit and 1 specimen (SUP 29140) from 'upper big shell' unit of lower member of Cliefden Caves Limestone, east of Large Flat.

Description. Laminar to hemispherical coenosteum composed of large convex cysts; reaches 150 mm. across, 90 mm. high. Latilaminae with sediment-filled spaces at irregular intervals between them. Broad mamelons developed.

Vertical section shows irregular-sized larger and smaller cysts with denticles arising from upper surfaces. Wall of cysts varies considerably in thickness, usually from 25 to 150 μ, exceptionally up to 500 μ. Cysts usually 1–3 mm. high, 4–10 mm. long, exceptionally up to 6 mm. high, 24 mm. long. Cysts spaced about 5 in 4 mm. vertically. Some cysts contain calcite infilling, others filled with sediment which seems to include a variety of algal? structures. In tangential section, broad mamelons prominent, with large curved cysts surrounding them. No astrorhizae.

Remarks. The species closely resembles *R. woyuensis* from the Tsinan Limestone (Middle? Ordovician) of Po-shan-hsien, province of Shantung, China (Ozaki 1938), and is therefore assigned to it. *R. amzassensis* Khalfina from the Upper Ordovician of the Siberian Platform (Khalfina 1960) is similar, but one of its type specimens exhibits three pillars.

Genus LABECHIA Milne-Edwards and Haime 1851

Type species. Monticularia conferta Lonsdale 1839.

Labechia regularis Yabe and Sugiyama 1930

Plate 120, fig. 1; Plate 121, figs. 3–6; Plate 124, figs. 1, 2

1930 *Labechia regularis* Yabe and Sugiyama, p. 56, pl. 18, figs. 5, 6; pl. 21, fig. 8.
1938 *Labechia regularis* Ozaki, p. 210, pl. 26, fig. 2*a–d*.
1955 *Labechia regularis* Yavorsky, p. 59, pl. 24, figs. 4, 5.

Material. 13 specimens from 'lower coral' unit, Licking Hole Creek (SUP 26236, 26238–9, 26242, 26248, 26252, 26255), and from 'mixed fauna' unit, west of shearing shed, Boonderoo (SUP 26231, 26240, 26243–4) and east of Large Flat (SUP 26237, 26245). Also occurs in lower part of Regan's Creek Limestone, south-east of Cargo, and in lower part of Reedy Creek Limestone between Molong and Copper Hill.

Description. Coenosteum hemispherical to laminar-encrusting, up to 100 mm. diameter, 80 mm. high. Latilaminae mainly from 3 to 15 mm. high. No astrorhizae.

Vertical section shows moderately thick, persistent pillars, 0·2–0·3 mm. in diameter; some exhibit lighter axial zones and some have zigzag edges, being broader just above point where it intersects lamina or dissepiment. In specimen SUP 26236, the laminae seem to persist as updomed extensions across pillars, and a pillar shows multiple branching (Pl. 121, fig. 6). At the upper boundary of a latilamina, pillars often appear to

extend up as rounded tubercles above level of adjacent lamina (Pl. 121, fig. 3). Laminae regularly spaced, flat to slightly concave, continuous between pillars over distances of 50 mm. or more in several examples; also smaller upcurved cysts (dissepiments) developed between laminae in certain areas, from 0·2 to 1 mm. wide, 0·1–0·3 mm. high. Wall thickness of dissepiments same as for laminae, from 25 to 50 μ thick. Laminae mainly spaced from 9 to 12 in 2 mm. vertically. Pillars usually between 0·1 and 0·5 mm. apart.

In tangential section, some pillars exhibit light-coloured centres suggesting that they were originally hollow, or originally infilled with different material from outer walls; others appear to be undifferentiated. Pillars mainly circular, but in some sections irregular to subangular in outline (Pl. 121, fig. 4).

Remarks. The New South Wales material particularly closely resembles *L. regularis*, as described by Yavorsky (1955) from Upper Ordovician localities in the basin of the Stony Tunguska River and a tributary of the Kotuy River, Siberian Platform. The Russian specimens appear to come from the Dolborsk stage, which is correlated with the upper Caradoc by Ivanovsky (1965). The type material described by Yabe and Sugiyama (1930) from Wu-hu-tzui, Fu-hsien, province of Liaotung, South Manchuria, probably from the Toufangkou Limestone of Middle? Ordovician age, seems to have fewer updomed cysts (dissepiments) but is otherwise similar.

L. (*Labechiella*) *mingshankouensis* (Ozaki) from the Ordovician of South Manchuria and Shantung also has regular laminae, but they are more widely spaced (4 to 5 in 2 mm.), and astrorhizae are exhibited (Ozaki 1938, p. 207).

Labechia variabilis Yabe and Sugiyama 1930

Plate 121, figs. 1, 2

1930 *Labechia variabilis* Yabe and Sugiyama, p. 54, pl. 17, figs. 1–9.
1938 *Labechia variabilis* Ozaki, p. 211, pl. 28, fig. 1*a–d.*

Material. 3 specimens (SUP 28163–4, 28248) from top of middle, massively bedded part of Regan's Creek Limestone, and 1 specimen (SUP 28251) from upper part of middle member of Cliefden Caves Limestone, on banks of Belubula River, west of Large Flat. Also occurs just below middle, thinly bedded unit of Bowan Park Limestone east of The Ranch.

Description. Coenosteum hemispherical, reaching 90×60 mm. across, 80 mm. high. One specimen (SUP 28251) encrusts *Tetradium cribriforme* (Etheridge), and is associated with heliolitids.

In vertical section, laminae gently undulating, concave upwards between closely spaced pillars to flat and gently convex. Laminae spaced about 4–6 in 2 mm. vertically;

EXPLANATION OF PLATE 121

Figs. 1, 2. *Labechia variabilis* Yabe and Sugiyama, ×5. 1, SUP 28248, vertical section; top of middle part of Regan's Creek Limestone. 2, SUP 28251, tangential section; upper part of middle member, Cliefden Caves Limestone, on south bank of Belubula River, west of Large Flat.

Figs. 3–6. *Labechia regularis* Yabe and Sugiyama. 3, 4, SUP 26240, ×5; 'mixed fauna' unit, lower member, Cliefden Caves Limestone, west of shearing shed, Boonderoo; 3, vertical section showing well-developed latilaminae; 4, tangential section exhibiting pillars with lighter centres, and irregular to subangular outlines. 5, 6, 'lower coral' unit, lower member, Cliefden Caves Limestone, Licking Hole Creek; 5, SUP 26242, ×5, tangential section; 6, SUP 26236, ×10, vertical section showing branching pillar.

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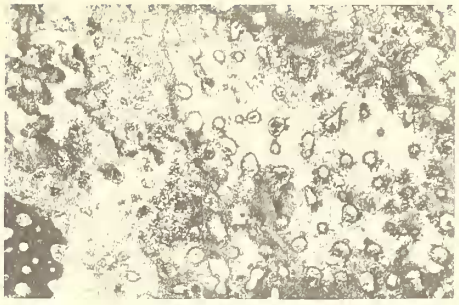

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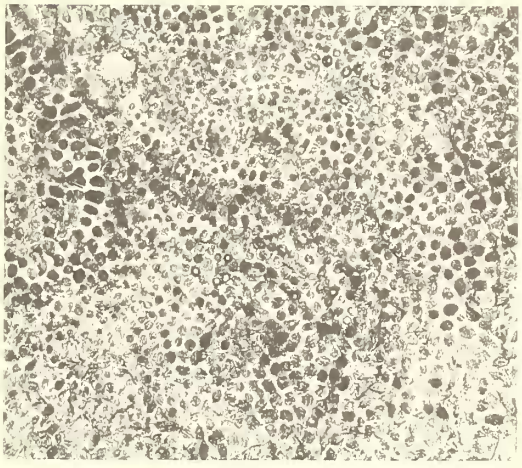

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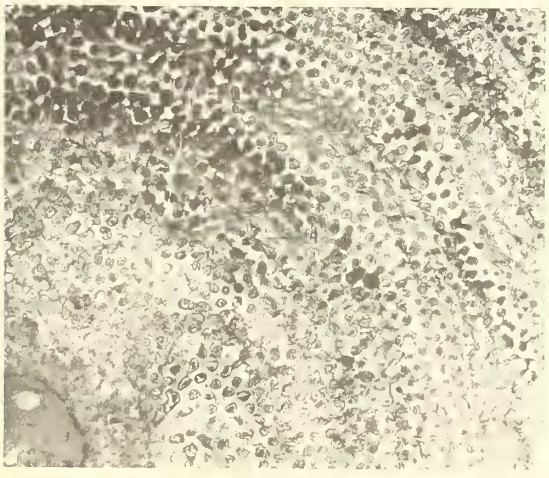

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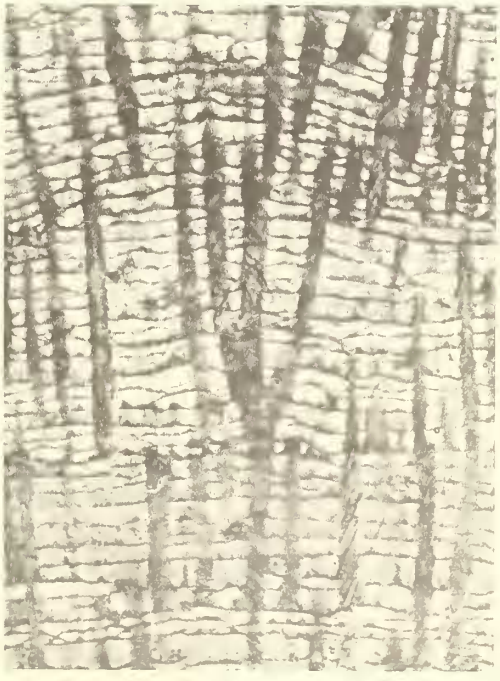

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WEBBY, Ordovician stromatoporoids from New South Wales

in few instances may be traced horizontally as continuous elements for more than 15 mm. Pillars appear to arise from more continuous laminae; persistent, extending to height of at least 8 mm., and cone-shaped across interlaminar spaces; branching pillar also observed (SUP 28251).

Tangential section shows great variability in diameter of pillars, from 0·1 to 0·5 mm. owing to the cone-shaped form; pillars spaced from 0·4 to 1·0 mm. apart, circular, oval to subangular in outline; some appear to have hollow centres. Irregular tube-like structures about 0·3 mm. wide may represent astrorhizae, but they cannot be confirmed in vertical section.

Remarks. The New South Wales specimens are closely comparable with *L. variabilis* from the Asian Ordovician, especially with the material described by Ozaki (1938) from South Manchuria. The only possible difference is the doubtful astrorhizae exhibited by one New South Wales specimen. The original description of *L. variabilis* by Yabe and Sugiyama (1930) is based on a number of specimens (syntypes) from various localities in South Manchuria, North China, and Korea, and needs revision.

Genus CRYPTOPHRAGMUS Raymond 1914

Type species. C. antiquatus Raymond 1914.

Cryptophragmus ? sp.

Plate 122, figs. 1, 2

Material. 2 silicified specimens (SUP 28169, 28171) from middle part of Regan's Creek Limestone. Also occurs in lower part of Bowan Park Limestone, Paling Yard Creek.

Description. Coenosteum cylindrical, unbranched, more than 40 mm. in length, 13–15 mm. in diameter; encrusted by colony of *Propora*. Axial column 7–10 mm. in diameter; axial cysts unknown. Latilaminae present, though not prominent. No astrorhizae or mamelons. Lateral cysts spaced 8–10 per 2 mm. radially; flat to concave between pillars; seem to be slightly oblique to the outer wall rather than parallel to it. Pillars have long, blade-like form; in silicified material, individual pillars can be traced as longitudinal grooves on outer surface of coenosteum for up to 7 mm.; spaced about 0·5–1 mm. apart around periphery of coenosteum.

Remarks. In the type species of *Cryptophragmus*, *C. antiquatum* Raymond, from the 'Blackriveran' of eastern North America, the pillars are described as 'oval to prismatic and tend to be round' (Galloway and St. Jean 1961, p. 19). The New South Wales specimens, in contrast, have blade-like pillars. They are therefore only tentatively assigned to the genus.

Genus CYSTISTROMA Etheridge 1895

Type species. C. donnellii Etheridge 1895.

Discussion. The original type material of *Labechia*? (*Cystistroma*) *donnellii* Etheridge is being redescribed by Dr. J. Pickett (Geological and Mining Museum, Geological Survey of New South Wales). Judging from the nature of preservation of the material it was probably collected originally from the 'lower coral' unit in the Fossil Hill section. This locality is near the Belubula River, in the Parish of Malongulli, as stated by Etheridge

(1895, p. 134). Pickett is raising the type species of *Cystistroma* to full generic rank, a procedure which I support.

Etheridge (1895) originally discussed the relationships between *Cystistroma* and *Labechia*, *Rosenella* and *Beatricea* Billings 1857 (= *Anlacera*), but not *Stromatocerium* Hall 1847. He observed (p. 139) that '*Cystistroma* appears to be a *Labechia* assuming certain *Rosenella*-like features'.

Cystistroma is closely allied to *Rosenella*, but is distinguished by having large pillars. It differs from *Labechia* and *Stromatocerium* in exhibiting denticles on the upper surface of cysts and sometimes on the outer surface of pillars. *Labechia* has regular, cylindrical pillars, whereas *Stromatocerium* has irregular to blade-like pillars. The variability of pillars in *Cystistroma* typically extends to both *Labechia* and *Stromatocerium* types. Only those with serrated outlines, owing to the intersection of denticles on outer surfaces of pillars, are distinct.

Denticles have only been positively identified on the upper surface of cysts in one species of *Stromatocerium*, namely, *S. canadense* Nicholson and Murie from the 'Blackriveran' and lower 'Trentonian' of North America (Galloway and St. Jean 1961, p. 62). Nestor (1964) recorded 'small monticles' on the upper surface of cysts and 'hollow' pillars in Estonian examples of *S. canadense* from the Oandu and Pirgu stages (= middle Caradoc and middle Ashgill, respectively), and *S. saknense* Nestor from the Oandu stage. Possibly these features result from incomplete preservation, and the 'monticles' are poorly preserved denticles. Perhaps these species should be assigned to *Cystistroma*.

Cystistroma donnellii Etheridge 1895

Plate 122, figs. 3–8; Plate 123, figs. 1–5; Plate 124, fig. 2

1895 *Labechia* (?) (*Cystistroma*) *donnellii* Etheridge, p. 134, pl. 14, figs. 1–6; pl. 15, figs. 1, 2; pl. 16, figs. 1–3.

Material. Based on specimens from following localities and horizons in lower member of Cliefden

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EXPLANATION OF PLATE 122

Figs. 1, 2. *Cryptophragmus*? sp., SUP 28169, ×4, middle part of Regan's Creek Limestone. 1, cross-section showing outer zone of cysts and pillars in silicified specimens. 2, oblique section showing linear grooves representing impressions of blade-like pillars on outer surface of specimen.

Figs. 3–8. *Cystistroma donnellii* Etheridge, ×5. 3, 4, SUP 26263, 'mixed fauna' unit, lower member, Cliefden Caves Limestone, west of shearing shed, Boonderoo. 3, vertical section with characters resembling *P.* aff. *poshanense*. 4, tangential section showing pillars with serrated outline owing to denticles on outer surfaces. 5, SUP 26258, vertical section showing denticles on outer surface of pillars; 'mixed fauna' unit, lower member of Cliefden Caves Limestone, east of Large Flat. 6, SUP 26259, tangential section; 'mixed fauna' unit, lower member, Cliefden Caves Limestone, near Cliefden Caves. 7, SUP 26250, assumed topotype, vertical section; 'lower coral' unit, lower member, Cliefden Caves Limestone, Fossil Hill. Typical representative of *C. donnellii* var. A (see also Pl. 123, fig. 1). 8, SUP 26262, vertical section; lower part of Reedy Creek Limestone, just south of Molong.

EXPLANATION OF PLATE 123

Figs. 1–5. *Cystistroma donnellii* Etheridge, ×5, assumed topotypes, 'lower coral' unit, lower member, Cliefden Caves Limestone, Fossil Hill. 1, SUP 26250, tangential section showing pillars with an oval outline. 2, 3, SUP 26268, vertical and tangential sections showing irregular, angular pillars. 4, 5, SUP 26267, vertical and tangential sections exhibiting angular, blade-like pillars. Figs. 2–5 depict representatives of *C. donnellii* var. B.